Q1. **(a)** Prove from first principles that two capacitors C_1 and C_2 connected in series can be replaced with an equivalent capacitance of $C_1C_2/(C_1+C_2)$. [2 marks]

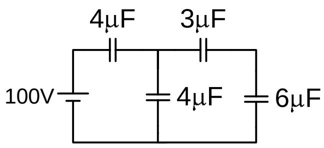


Figure Q1-(b)

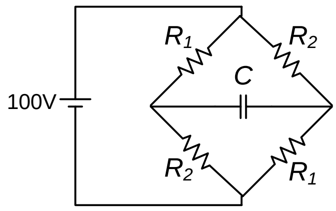
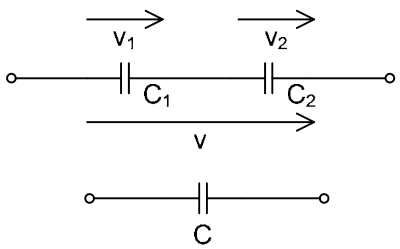


Figure Q1-(c)

(b) Find the voltage across each capacitor of the circuit in Figure Q1-(b). [4 marks]
(c) Find an expression for the charging time constant of the capacitor C shown in Figure Q1-(c). Also find the steady state voltage across the capacitor. [4 marks]

ANSWER

(a) Let Q_1 be the charge on C_1 and Q_2 charge on C_2, then $Q_1 = C_1V_1$ and $Q_2 = C_2V_2$.
For the equivalent capacitor C, we have $Q = CV$
Since the two capacitors are in series,
$Q_1 = Q_2 = Q$, Hence we have,



$$V = V_1 + V_2 = \frac{Q}{C_1} + \frac{Q}{C_2} = Q \cdot \left[\frac{1}{C_1} + \frac{1}{C_2}\right],$$

Comparing with $Q = CV$, we get

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \text{ or}$$

$$C = \frac{C_1C_2}{C_1 + C_2}$$

(b) The equivalent circuits are given below,

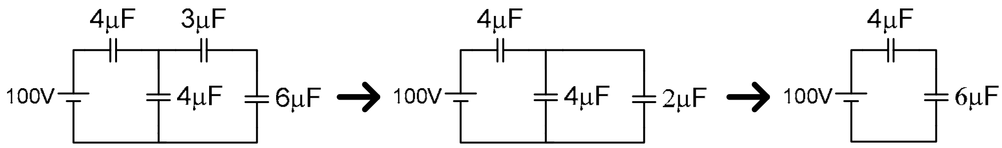
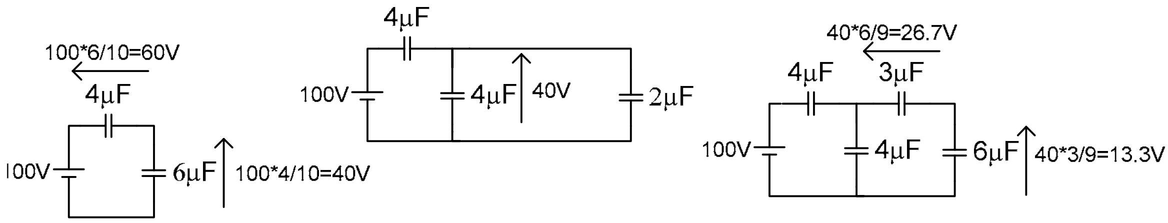


Figure Q1-(b)

Using the voltage division rule, we get the following



(c) Get the Thevenin's equivalent across the capacitor.

$R_{th} = (R_1||R_2) + (R_1||R_2)$, therefore, $R_{th} = 2.\ R_1.R_2/(R_1+R_2)$
Also,

$$E_{th} = E\left(\frac{R_2}{R_1+R_2} - \frac{R_1}{R_1+R_2}\right) = E\left(\frac{R_2-R_1}{R_1+R_2}\right)$$

Hence,
The time constant = R_{th}. C = 2. $R_1.R_2.C/(R_1+R_2)$

Final Voltage = $E_{th} = 100.\left(\frac{R_2-R_1}{R_1+R_2}\right)$

Q2. (a) Write a differential equation relating output current *i(t)* to the input voltage *v(t)* for the circuit in Figure Q2. [5 marks]

(b) By means of the differential equation derived above, answer the following.

- **i.** What is the order of the differential equation? How is the order of the differential equation related to the circuit in question? [1 mark]
- **ii.** If the input voltage *v(t)* is a DC source of magnitude *E*, what is the current at steady state? [1 mark]
- **iii.** If the input voltage *v(t)* is an AC source of angular frequency ω, derive an expression for the input impedance of the circuit. [2 marks]
- **iv.** Validate your answer in part (iii) above using AC theory. [1 mark]

ANSWER

(a) We can write the following equations for V_1, V_2 and V.

$$V = V_1 + V_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$i = i_1 + i_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$V_1 = L_1\frac{di_2}{dt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$V_1 = \frac{1}{C_1}\int i_1\, dt \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$V_2 = iR_2 + L_2\frac{di}{dt} \ldots\ldots\ldots\ldots\ldots \quad (5)$$

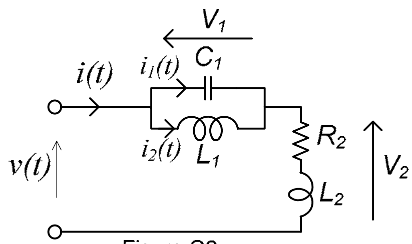


Figure Q2

Differentiating equation (4) twice yields $\frac{di_1}{dt} = C_1\frac{d^2V_1}{dt^2}$, and combining with equation (3),

we get, $\frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt} = C_1\frac{d^2V_1}{dt^2} + \frac{V_1}{L_1}$, or $\frac{1}{C_1}\frac{di}{dt} = \frac{d^2V_1}{dt^2} + \frac{V_1}{L_1C_1}$ ………… (6)

Also, differentiating equation (5) twice yields $R_2\frac{d^2i}{dt^2} + L_2\frac{d^3i}{dt^3} = \frac{d^2V_2}{dt^2}$ …… (7)

Adding (6) and (7),

$$\frac{1}{C_1}\frac{di}{dt} + R_2\frac{d^2i}{dt^2} + L_2\frac{d^3i}{dt^3} = \frac{d^2V_1}{dt^2} + \frac{V_1}{L_1C_1} + \frac{d^2V_2}{dt^2} \ldots\ldots\ldots\ldots \quad (8)$$

Substituting from equation (1) and its derivatives, (8) becomes

$$\frac{1}{C_1}\frac{di}{dt}+R_2\frac{d^2i}{dt^2}+L_2\frac{d^3i}{dt^3}=\frac{d^2V}{dt^2}+\frac{1}{L_1C_1}(V-V_2)$$

$$=\frac{d^2V}{dt^2}+\frac{1}{L_1C_1}\left(V-iR_2-L_2\frac{di}{dt}\right)$$

Re-arranging the terms,

$$\boxed{\frac{d^3i}{dt^3}+\frac{R_2}{L_2}\cdot\frac{d^2i}{dt^2}+\frac{1}{C_1}\left(\frac{1}{L_1}+\frac{1}{L_2}\right)\frac{di}{dt}+\frac{R_2}{L_1L_2C_1}i=\frac{1}{L_2}\cdot\frac{d^2V}{dt^2}+\frac{1}{L_1L_2C_1}\cdot V}$$

(b) Using the above differential equation,

i. The order of the differential equation is 3. This is because the circuit has 3 independent energy storing elements.

ii. To find steady state current, substitute *di/dt*= 0 and *dV/dt=0* (all higher derivatives are also zero). Thus, $I = E/R_2$.

iii. Substitute $d/dt = j\omega$, (and swapping left and right hand sides)

$$\left[\frac{1}{L_2}\cdot(j\omega)^2+\frac{1}{L_1L_2C_1}\right]\cdot V=\left[(j\omega)^3+\frac{R_2}{L_2}\cdot(j\omega)^2+\frac{1}{C_1}\left(\frac{1}{L_1}+\frac{1}{L_2}\right)(j\omega)+\frac{R_2}{L_1L_2C_1}\right]\cdot I$$

$$\left[-\frac{1}{L_2}\omega^2+\frac{1}{L_1L_2C_1}\right]\cdot V=\left[-j\omega^3-\frac{R_2}{L_2}\cdot\omega^2+j\frac{1}{C_1}\left(\frac{1}{L_1}+\frac{1}{L_2}\right)\omega+\frac{R_2}{L_1L_2C_1}\right]\cdot I$$

$$\frac{(1-\omega^2L_1C_1)}{L_1L_2C_1}\cdot V=\frac{\left[-j\omega^3L_1L_2C_1-R_2L_1C_1\omega^2+j(L_1+L_2)\omega+R_2\right]}{L_1L_2C_1}\cdot I$$

$$\frac{V}{I}=\frac{R_2(1-\omega^2L_1C_1)+j\omega(L_1+L_2-\omega^2L_1L_2C_1)}{(1-\omega^2L_1C_1)}$$

$$=R_2+j\omega L_2+\frac{j\omega L_1}{(1-\omega^2L_1C_1)}$$

iv. Using AC theory, the impedance is

$$Z=R_2+j\omega L_2+\frac{j\omega L_1\cdot\frac{1}{j\omega C_1}}{j\omega L_1+\frac{1}{j\omega C_1}}$$

$$=R_2+j\omega L_2+\frac{j\omega L_1}{(1-\omega^2L_1C_1)}$$

Q3. **(a)** Derive an expression for the total energy stored in the coupled circuit in Figure Q3-(a). [2 marks]

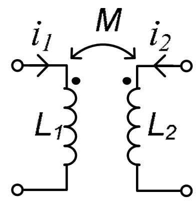


Figure Q3-(a)

(b) The circuit in Figure Q3-(b) is supplied by a sinusoidal voltage source V_s of variable frequency. The output V_{out} is taken across the inductor.

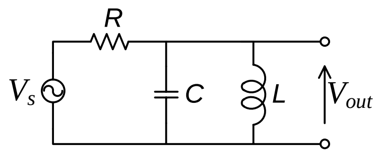


Figure Q3-(b)

i. Write an expression for the output voltage V_{out} as a function of the input voltage V_s . [1 mark]

ii. Find an expression for the resonance frequency of the circuit. [1]

iii. Show that half-power frequencies are given by, [2 marks]

$$f_1, f_2 = \pm\frac{1}{4\pi RC} + \frac{1}{2\pi}\sqrt{\frac{1}{(2RC)^2} + \frac{1}{LC}}$$

iv. If the circuit is to be designed with a resonance frequency of 3.2 kHz and a bandwidth of 1 kHz, calculate the appropriate values for L and C, given that R = 2.0 kΩ. [2 marks]

v. With the circuit parameters as found in part (iv) above, determine the output voltage at the frequencies of f_1 and f_2, when V_s = 10V. [2 marks]

ANSWER

(a) Total energy stored

$$\begin{aligned}W &= \int v_1 i_1 dt + \int v_2 i_2 dt \\ &= \int\left(L_1\frac{di_1}{dt} + M\frac{di_2}{dt}\right)i_1 dt + \int\left(L_2\frac{di_2}{dt} + M\frac{di_1}{dt}\right)i_2 dt \\ &= \int L_1 i_1 di_1 + \int L_2 i_2 di_2 + M\int(i_1 di_2 + i_2 di_1) \\ &= \tfrac{1}{2}L_1 i_1^2 + \tfrac{1}{2}L_2 i_2^2 + M i_1 i_2\end{aligned}$$

(b) (i). The output voltage is given by,

$$V_{out} = \frac{Z}{R+Z}\cdot V_s \text{ ,where Z is the impedance of L and C in parallel.}$$

$$= \frac{j\omega L/(1-\omega^2 LC)}{R + j\omega L/(1-\omega^2 LC)}\cdot V_s$$

$$= \left(\frac{j\omega L}{R(1-\omega^2 LC) + j\omega L}\right)\cdot V_s$$

$$= \left[\frac{1}{1 - j\dfrac{R}{\omega L}(1-\omega^2 LC)}\right]\cdot V_s$$

(ii). The resonance frequencies are given by unity power factor,

$$\frac{R}{\omega L}(1-\omega^2 LC) = 0$$

$$\omega_0 = \sqrt{\frac{1}{LC}}$$

(iii). At half-power frequencies,

$$\left[\frac{1}{1-j\frac{R}{\omega L}\left(1-\omega^2 LC\right)}\right]\cdot V_s = \frac{V_s}{\sqrt{2}},$$ Since at resonance the output voltage is V_s

i.e., $\frac{R}{\omega L}\left(1-\omega^2 LC\right) = \pm 1$

Taking the positive sign,

$$R-\omega^2 RLC = \omega L$$

$$\omega^2 + \left(\frac{1}{RC}\right)\omega - \left(\frac{1}{LC}\right) = 0$$

$$\omega_1 = -\frac{1}{2RC} + \sqrt{\frac{1}{(2RC)^2} + \frac{1}{LC}},$$ Note that the other solution yields a negative frequency and hence it is ignored.

Taking the nagative sign,

$$\omega^2 - \left(\frac{1}{RC}\right)\omega - \left(\frac{1}{LC}\right) = 0$$

$$\omega_2 = \frac{1}{2RC} + \sqrt{\frac{1}{(2RC)^2} + \frac{1}{LC}},$$ Note that the other solution yields a negative frequency and hence it is ignored.

$$f_1, f_2 = \pm\frac{1}{4\pi RC} + \frac{1}{2\pi}\sqrt{\frac{1}{(2RC)^2} + \frac{1}{LC}}$$

(iv). Resonnance frequency,

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} = 3200 \text{ Hz}$$

$$LC = \frac{1}{4\pi^2 f_0^2} = 2.474\times 10^{-9}$$

Bandwidth is given by,

$$f_1 - f_2 = 2\times\frac{1}{4\pi RC} = 1000 \text{ Hz}$$

$$RC = \frac{1}{2\pi(\text{BW})} = 1.592\times 10^{-4}$$

Thefore, C = 0.08 μF and L = 31 mH.

(v). The output voltage at half-power frequencies must be 1/√2 of peak output at resonance. Since the peak output is 10V, the output at half-power frequencies is 7.07V.

Q4. **(a)** For the circuit in Figure Q4, find the input impedance across *XY*. [2 marks]
(b) Find the short circuit current through *XY*. [2 marks]
(c) Find the Norton's equivalent circuit across *XY*. [2 marks]
(d) If the voltage source is moved to the terminals *XY*, What would be the Norton's equivalent circuit across *AB*? [2 marks]
(e) Are the two Norton's equivalent circuits identical? Comment on your results. [2 marks]

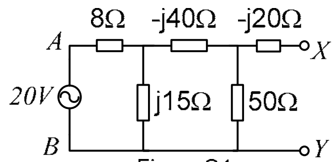


Figure Q4

ANSWER

(a) The impedance across XY, is Z_{XY} .

$$Z_1 = 8 \| j15 = 6.2284 + j3.3218$$
$$Z_2 = Z_1 - j40 = 6.2284 \text{ -}j36.6782$$
$$Z_3 = Z_2 \| 50 = 18.8100 \text{ -}j20.3455$$
$$Z_{XY} = Z_3 - j20 = 18.8100 \text{ -}j40.3455$$
$$Y_{XY} = \frac{1}{Z_{XY}} = 0.0095 + j0.0204$$

(b) First, find the total impedance when XY are short circuited.

$$Z_4 = -j20 \| 50 = 6.8966 \text{ - } j17.2414$$
$$Z_5 = Z_4 - j40 = 6.8966 \text{ - } j57.2414$$
$$Z_6 = Z_5 \| j15 = 0.8471 + j20.1882$$
$$Z_{sc} = Z_6 + 8 = 8.8471 + j20.1882$$
$$\therefore I_1 = \frac{20}{8.8471 + j20.1882} = 0.3642 \text{ - } j0.8311, \text{ this is the s/c current at the source.}$$

Using current division rule successively,

$$I_2 = \frac{j15}{Z_5 + j15} I_1 = \text{-}0.0790 + j\,0.3080$$
$$I_{sc} = \frac{50}{50 - j20} I_2 = \text{-}0.1744 + j0.2383$$

(c) Hence, the Norton equivalent circuit has a current source of (-0.1744 + *j*0.2383) A and a parallel admittance of Y_{XY} = 0.0095 + *j*0.0204

(d) When the voltage source is moved to XY, using the reciprocity theorem, the short circuit current across AB must be the same as the short circuit current I_{sc} found earlier.
By inspection, the input impedance across AB, must be the same as Z_{sc} calculated in part (b) above.

(e) The two equivalent circuits are not identical. However, they have the same current source but different admittances in parallel.

Q5. **(a)** An alternating voltage source V_s has an internal impedance of $r + jx$. Find an expression for the purely resistive load R_p which when connected to the source, maximises the real output power. [4 marks]

(b) Derive an expression for the source efficiency for the above circuit when it delivers maximum power. [3 marks]

(c) You need to design a 10V, AC source such that for purely resistive loads, it delivers a maximum of 12.5W at a source efficiency of 75 percent. Determine the internal impedance of the source. [3 marks]

ANSWER

(a) When a purely resistive load R is connected, the power output is given by

$$P = I^2 R = \left|\frac{V}{r + jx + R}\right|^2 \cdot R$$

$$= \frac{V^2}{(R+r)^2 + x^2} \cdot R$$

For maximum power, $dP/dR = 0$

$$\frac{dP}{dR} = V^2 \cdot R(2(r+R)) - V^2 \cdot \left[(r+R)^2 + x^2\right] \cdot 1 = 0$$

$$2R(r+R) = (r+R)^2 + x^2$$

$$R^2 = r^2 + x^2$$

$$\therefore R_p = \sqrt{r^2 + x^2}$$

(b) The source efficiency at maximum power,

$$\eta = \frac{\text{Output Power}}{\text{Total Power at source}} = \frac{|I_m|^2 R_p}{|I_m|^2 (R_p + r)} = \frac{\sqrt{r^2 + x^2}}{r + \sqrt{r^2 + x^2}}$$

$$= \frac{\sqrt{1 + \left(x/r\right)^2}}{1 + \sqrt{1 + \left(x/r\right)^2}}$$

(c) The maximum power delivered to the load,

$$P_L = |I_m|^2 R_p$$

$$= \frac{V^2}{\left(r + \sqrt{r^2 + x^2}\right)^2 + x^2} \cdot \sqrt{r^2 + x^2}$$

$$= \frac{V^2}{2(r^2 + x^2) + 2r\sqrt{r^2 + x^2}} \cdot \sqrt{r^2 + x^2}$$

$$= \frac{V^2}{2r} \cdot \left[\frac{\sqrt{1 + \left(x/r\right)^2}}{1 + \left(x/r\right)^2 + \sqrt{1 + \left(x/r\right)^2}}\right]$$

From the equation for efficiency, $\eta = 0.75$, we get $(x/r)^2 = 8$ or $x/r = 2.828$.
By substituting for x/r in equation for P_L, we get, $r = 1.0\Omega$. Hence, $x = 2.828\Omega$.

Q6. **(a)** Find the ABCD parameters for the transformer circuit in Figure Q6-(a). [5 marks]

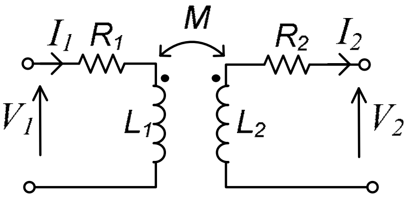


Figure Q6-(a)

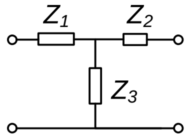


Figure Q6-(b)

(b) Find appropriate values for Z_1, Z_2 and Z_3 of the T-network in Figure Q6-(b) such that it is equivalent to the transformer circuit in Figure Q6-(a). [5 marks]

ANSWER

(a) Writing the Kirchhoff's law for the two loops,

$$V_1 = I_1R_1 + j\omega L_1 I_1 - j\omega M I_2$$
$$V_2 = I_2R_2 - j\omega L_2 I_2 + j\omega M I_1$$

Using the above equations together with the definitions for A, B, C and D,

$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} = \frac{R_1I_1 + j\omega L_1 I_1}{j\omega M I_1} = \frac{R_1 + j\omega L_1}{j\omega M}$$

$$B = \left.\frac{V_1}{V_2}\right|_{V_2=0} = \frac{I_1R_1 + j\omega L_1 I_1 - j\omega M I_2}{I_2} = (R_1 + j\omega L_1)\frac{I_1}{I_2} - j\omega M$$

But from second equation above, $\dfrac{I_1}{I_2} = \dfrac{(R_2 + j\omega L_2)}{j\omega M}$

$$\therefore B = (R_1 + j\omega L_1)\frac{(R_2 + j\omega L_2)}{j\omega M} - j\omega M = \frac{1}{j\omega M}\left[(R_1 + j\omega L_1)(R_2 + j\omega L_2) - \omega^2 M^2\right]$$

$$C = \left.\frac{I_1}{V_2}\right|_{I_2=0} = \frac{I_1}{j\omega M I_1} = \frac{1}{j\omega M}$$

$$D = \left.\frac{I_1}{I_2}\right|_{V_2=0} = \frac{(R_2 + j\omega L_2)}{j\omega M}$$

(b) For the T-network,

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & Z_1 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ Y_3 & 1 \end{bmatrix}\begin{bmatrix} 1 & Z_2 \\ 0 & 1 \end{bmatrix}$$
$$= \begin{bmatrix} (1 + Z_1Y_3) & Z_2 + (1 + Z_2Y_3)Z_1 \\ Y_3 & (1 + Z_2Y_3) \end{bmatrix}$$

By comparing the two sets of parameters, For parameter C,

$Y_3 = \dfrac{1}{j\omega M}$ which yields $Z_3 = j\omega M$

For parameter A,

$(1 + Z_1 Y_3) = \dfrac{R_1 + j\omega L_1}{j\omega M}$

Substituting for Y_3 , $Z_1 = R_1 + j\omega L_1 - j\omega M = R_1 + j\omega(L_1 - M)$

Similarly for parameter C,

$(1 + Z_2 Y_3) = \dfrac{R_2 + j\omega L_2}{j\omega M}$

Substituting for Y_3 , $Z_2 = R_2 + j\omega L_2 - j\omega M = R_2 + j\omega(L_2 - M)$

Q7. **(a)** Using the first principles and general properties of Laplace transform, find the Laplace transform of causal time function $f(t) = e^{-at}\sin\omega t$. [2 marks]

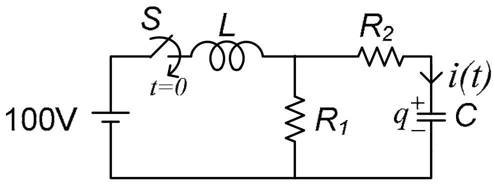


Figure Q7

(b) In the circuit of Figure Q7, the capacitor has an initial charge of 500μC. If the switch *S* is closed at *t* = 0, using Laplace transform method, find an expression in time *t* for the subsequent variation of current *i(t)*. [5 marks]

(c) If *L*=1 mH, R_1=400Ω, R_2=600Ω and *C*=25μF, determine the following values related to *i(t)*, [2 marks]

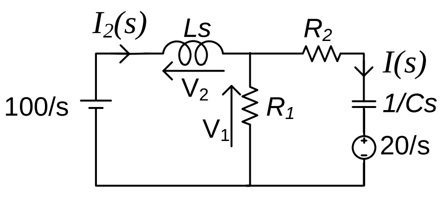
- **iv.** initial current,
- **v.** time at which current becomes zero momentarily,
- **vi.** peak value of current and the time it occurs,
- **vii.** steady state value of current.

(d) Sketch, approximately to scale, the current wave form *i(t)* from *t* = 0 to 100ms. [1 mark]

ANSWER

(a) See class notes for the Laplace transform of $\sin\omega t$. Multiplying by e^{-at} in time domain will have the effect of shifting s→(s+a) in frequency domain. Combining these two results, we get $F(s) = \dfrac{\omega}{(s+a)^2 + \omega^2}$.

(b) When converted to frequency domain the circuit becomes (the initial charge is equal to 20V step input in series with the capacitor),



And applying Kirchhoff's law's,

$$V_1 = R_2\, I(s) + \frac{1}{Cs} I(s) + \frac{20}{s} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

$$\frac{100}{s} = V_1 + V_2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

Equation (2) yields,

$$\frac{100}{s} = V_1 + Ls \cdot I_2(s)$$

$$= V_1 + Ls \cdot \left(I(s) + \frac{V_1}{R_1} \right)$$

$$= V_1 \left(1 + \frac{Ls}{R_1} \right) + Ls \cdot I(s)$$

Substituting for V_1 from (1),

$$= \left(R_2 I(s) + \frac{1}{Cs} I(s) + \frac{20}{s} \right) \cdot \left(1 + \frac{Ls}{R_1} \right) + Ls \cdot I(s)$$

$$= \left[\left(R_2 + \frac{1}{Cs} \right) \left(1 + \frac{Ls}{R_1} \right) + Ls \right] \cdot I(s) + \frac{20}{s} + \frac{20L}{R_1}$$

Solving for *I(s)*,

$$I(s) = \frac{80 - 20\left(L/R_1 \right) s}{L\left(\frac{R_1 + R_2}{R_1} \right) s^2 + \left(\frac{L + R_1 R_2 C}{R_1 C} \right) s + \frac{1}{C}}$$

The above expression has a second order denominator and a first order numerator. In general this expression can be factored as,

$$I(s) = k \cdot \frac{a - b}{(s + a)(s + b)}$$

Hence the time domain expression for current *i(t)* is,

$$i(t) = k_1 \cdot e^{-at} - k_2 \cdot e^{-bt}$$

(c) Substituting values,

$$I(s) = \frac{80 - 5 \times 10^{-5} s}{0.0025 s^2 + 600 s + 40000}$$

$$= \frac{3.2 \times 10^4 - 0.02 s}{s^2 + 2.4 \times 10^5 s + 1.6 \times 10^7}$$

Using partial fraction expansion, we get

$$I(s) = \frac{0.1334}{(s + 66.7)} - \frac{0.1534}{(s + 2.4 \times 10^5)}$$

In time domain,

$$i(t) = 0.1334 \cdot e^{-66.7t} - 0.1534 \cdot e^{-2.4 \times 10^5 t}$$

The initial current: substitute t=0;

i(0) = 0.1334 – 0.1534 = 20 mA.

The at which current crosses the zero axis:

$$0.1334 \cdot e^{-66.7t} - 0.1534 \cdot e^{-2.4\times10^5 t} = 0$$

$$0.1334 \cdot e^{-66.7t} = 0.1534 \cdot e^{-2.4\times10^5 t}$$

Taking log on both sides,

$$\ln(0.1334) - 66.7t = \ln(0.1534) - 2.4\times10^5 t$$

Thus $t_0 = 0.58\times10^{-6}$ sec.

Peak value of current:

$$\frac{di}{dt} = 0.1334\times(-66.7)\cdot e^{-66.7t} - 0.1534\times\left(-2.4\times10^5\right)\cdot e^{-2.4\times10^5 t} = 0$$

$$8.89778\times e^{-66.7t} = 36816\times e^{-2.4\times10^5 t}$$

$$-66.7t = \ln\left(\frac{36816}{8.89778}\right) - 2.4\times10^5 t$$

$$2.3993\times10^5 t = 8.3279$$

$$\mathrm{t} = 34.7\times10^{-6}$$

Corresponding current would be

$$i(t) = 0.1334\cdot e^{-66.7\times34.7\times10^{-6}} - 0.1534\cdot e^{-2.4\times10^5\times34.7\times10^{-6}}$$

$$= 133\ \mathrm{mA}$$

The steady state value of current is zero.